QUARTERLY REPORT

1. **Contract Number:** DAMD17–91–C–1081

2. **Report Date:** 9 June 1993

3. **Reporting Period:** 16 February 1993 to 15 May 1993

4. **Principal Investigator:** Dr. Robert W. Verona

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6. **Institution:** UES, Inc.
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7. **Project title:** Development of Data Packages on the Human Visual Response with Electro-optical Displays

8. **Current staff, with percent effort of each on project:**

NAME	TITLE	HOURS	% OF EFFORT
Dr. Robert W. Verona	Engineering Psychologist	472	92%
Dr. Victor Klymenko	Research Psychologist	496	97%
Mr. Howard H. Beasley	Electronics Technician	480	94%
Mr. John S. Martin	Electro–optics Technician	457	89%

* 512 hours were available this reporting period not including holidays. The above hours are the actual hours worked (sick leave and vacation have been subtracted).

9. **Contract expenditures to date:**

Personnel	$472,324.11	Equipment & Supplies	$ 3,935.06
Travel	7,824.83	Other	4,122.41
		TOTAL*	$488,206.41

* Does not include facilities capital and G&A expense.

10. **Comments on administrative and logistics matters.**

Building construction has disrupted the office work area for most of this reporting period. Most of our administrative functions have been moved to the laboratory area until the construction project is completed.

11. Scientific Progress:

Physical Measurements:

The primary effort last quarter was directed toward developing and validating image intensifier device performance measurements. This quarter's primary efforts have been directed toward the measurement of three different types of image intensifier based night vision devices in conjunction with a hyperstereo flight test.

The objective of the hyperstereo flight test is to determine whether the hyperextension of the oculars greater than the aviators normal interpupillary distance (IPD) produces unacceptable flight performance. Devices with three different interpupillary distances were investigated: normal, 2X and 4X. All three night vision devices were equipped with third generation image intensifier tubes.

One of the devices was the Aviator's Night Vision Imaging System (ANVIS). It is a binocular, direct-view image intensifier device. Each ocular contains an objective lens, intensifier tube, and simple magnifier eyepiece. The aviator has an independent, 40^{0} field-of-view (FOV), optical channel for each eye. The oculars are spaced at the same IPD as the aviator's eyes and provide a fully overlapped 40^{0} FOV. There is a look-under/look-around capability with the ANVIS, but no look-through capability. The ANVIS is the standard issue device for U.S. Army aviation; its performance was used as a baseline against which the performance characteristics of the other devices were measured.

Another device was the Night Vision Devices' Eagle Eye system. It uses a prism combiner to add the intensified image over the direct view image. Each ocular contains an objective lens, prism, intensifier tube, magnifier, and prism combiner. The aviator has an independent, 40^{0} FOV, channel for each eye. The oculars are spaced at about twice the normal IPD and provide a fully—overlapped 40^{0} FOV. With this device there is a look-through capability, but only a limited look-under/look-around capability. The conformal configuration of this device is not as efficient as the ANVIS. The additional optical elements in the image input and image output paths reduce the efficiency of the image intensifier tube. The tube gain must be set considerably higher in the Eagle Eye to provide the same system gain as the ANVIS.

The third device was the Honeywell Night Vision System. It uses a monolithic afocal relay combiner (MONARC) to add an intensified image and a CRT image to the direct view image. Each ocular contains an objective lens, prism, intensifier tube, prism, lens, and MONARC. The aviator has an independent, 35^{0} FOV, optical channel for each eye with an intensified and/or CRT image source. The oculars are spaced at about four times the normal IPD and can provide either a fully or partially overlapped FOV. With this device there is a look—through, look—under, and look—around capability. The configuration of this device is not as efficient as the ANVIS. The additional optical elements in the image input and image output

paths reduce the efficiency of the image intensifier tube. The tube gain must be set considerably higher in the Honeywell MONARC system to provide the same system gain as the ANVIS.

The subjective resolution of all three type systems tested was equivalent at moon and quarter moon light levels, but the MONARC and Eagle Eye systems' performance was significantly less than ANVIS for starlight and below conditions. The MONARC system performed better than the Eagle Eye system. The MONARC system uses standard ANVIS intensifier tubes with a higher gain setting. The Eagle Eye system uses a modified AN/PVS-7 intensifier tube with a higher gain setting. Although with the higher gain settings however, the light losses in the prisms and combiners cause the output intensity to be significantly lower on these systems than with the ANVIS, thereby resulting in lower visual acuity at low light levels. The system gain, subjective resolution, magnification, distortion, and FOV measurements were performed on both oculars of all devices. These data were cataloged and provided to MAJ. Rabin. Confirmation of the system performance was accomplished with each pair of aviators prior to each flight test.

Physical measurements were also made on the high resolution color monitor used in the perceptual studies. Both static and dynamic performance measurements were developed and performed. Fixtures were made to hold the photometer with its slit parallel to the 45^{0} spatial patterns. Additional equipment was acquired for the dynamic measurements. An analog filter was needed to smooth the high frequency photometer output, and an oscilloscope was needed to display the modulated photometer output as a function of time. Repeatability measurements were made to monitor and insure the consistency of the results. Some of the procedures continue to be refined to improve the reliability, accuracy, and speed of the measurements.

Psychophysical Measurements:

Last quarter, testing of aviators under the protocol "Psychophysical Assessment of Visual Parameters in Electro-optical display systems" was completed. The "limits" experiment (Experiment 1A in the protocol); and the previously completed "luning" experiment (Experiment 2 in the protocol), completes this protocol. Subjects were run in a contrast matching task which served as training for the protocol sessions. Also run were subjects in a "fragmentation" experiment under a protocol amendment. Descriptions for each of these experiments is as follows:

For the limits experiment, the results were presented at the Association for Research in Vision and Ophthalmology in May 1993 in the paper titled "Binocular Viewing Mode Affects Spatio-Temporal Contrast Threshold." In brief, this experiment measured the contrast threshold of a series of band limited probe stimuli with different spatial and temporal frequency characteristics at four positions across the visual FOV. This was done for the three binocular display modes: the convergent, the divergent and the complete overlap display mode. In brief, the most important results indicated that for high spatial frequency probe stimuli, presented in

monocular parts of the FOA, contrast threshold was higher in the divergent than in the convergent display mode. This difference in threshold was greatest for positions near the binocular border. A copy of the convention paper is included as Appendix A. Currently more accurate physical contrast measurements of the computer defined contrasts used in the experiment for the different probe stimulus spatial and temporal frequencies are being taken. A lab report and a paper will be written for possible publication in the Journal of the Optical Society of America.

The completed luning experiment, as described in the previous quarterly report, has been written in a first draft and circulated around the laboratory for review. Based upon the favorable review comments, the draft will be prepared as a formal laboratory report and as a paper for possible submission to the Human Factors and Ergonomics Society Journal. A copy of the draft is included as Appendix B.

In the luning experiment, several different display area grey levels were tested against a black background. Since completion of the experiment, informal testing of various stimulus display conditions has continued. These have included different brightness levels and different colors, opponent and non-opponent, for the background as well as the display area. These additional observations confirm the notion that luning is primarily a binocular rivalry phenomenon, albeit one that is effected in complex ways by factors such as the binocular border and the region of foveation, as well as the display mode.

A number of the protocol subjects were run in a contrast matching experiment, where aviators matched the contrast of a probe in different positions to a standard stimulus. The data will soon be analyzed although, informally they do not look very stable or systematic.

A brief "fragmentation" experiment under a protocol amendment (dated March 26, 1993) was conducted. In this experiment, aviators viewed two displays simultaneously, one above the other, to make direct comparisons, unlike the luning experiment where they were viewed individually. In this experiment, the task was to indicate which image was more stable, that is, had less of a tendency to fragment. This is analogous to the magnitude of luning in the luning experiment. A number of factors were considered, including relative areas of the monocular fields, and the monocular and binocular overlap regions, as well as convergent and divergent display mode. Briefly, the results indicated that for central fixation, the divergent displays fragmented more, and the displays with the largest binocular overlap area fragmented least. An additional lab report will be prepared on these experiments.

Milestones:

Planned efforts for the next quarter will be focused on the completion of several technical reports that are being written. A technical report on the dynamic display measurements and several reports based on the perception studies will be released this quarter. Measurements on

the night vision devices used in the flight test will continue to be collected this quarter.

In addition, a literature search and software development for further studies and protocol amendments will be conducted. Also, the completion of the physical contrast measurements of the spatio-temporally modulated probe stimuli in the limits experiment is expected.

Appendix A -- First Draft, Luning Paper.

Appendix B -- ARVO 1993 Limits Paper.